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Dancing Exercise Enhances Metabolic Functions via Hypercortisolism-Mediated Inhibition of Inflammatory Cytokines in Healthy Adult Volunteers

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Abstract

Regular physical activity has been proven to improve metabolism, slow aging, and decrease the likelihood of various health conditions such as obesity, type 2 diabetes, and cardiovascular disorders. Hence, dancing was evaluated for its effects on cardiovascular, liver enzymes, and biochemical markers among healthy adults. Forty (40) healthy adults (20-40 years old) were chosen for the study, with an average age calculated. Those with certain health conditions or habits were not allowed to participate. Twenty (20) men and 20 women were chosen for the study, which involved dancing for 15 minutes a day, five days a week,

for four weeks. Pre- and post-dancing groups were compared to measure any changes. Results indicated positive effects on health and well-being. The two groups were compared to analyze changes to cardiovascular, liver enzymes, and lipid profiles over a 4-week dance intervention. Both groups received assessments before and after the program, with the initial assessment taking place at 0 weeks and a follow-up at 4 weeks. This study found that a 4-week period of dancing exercise improved cardiovascular and lipid profiles ($p < 0.05$) in both genders. These favorable impacts were reflected in lower systolic and diastolic blood pressure, decreased total cholesterol and triglycerides, and lowered LDL with corresponding increases in HDL. This study found that participating in a tailored dance exercise program decreased glucose, insulin, and HOMA index levels compared to pre-exercise levels. Additionally, levels of ALT, AST, and GGT dropped considerably, while ALP and LDH also decreased. Kidney function, including aminotransferase, creatinine, and uric acid, was also reduced after 24 hours of post-dancing exercise. Twenty-four hours of Post-dancing exercise was found to decrease serum IL-6, CRP, and stress hormones (epinephrine and cortisol) levels as well as increased IL-10 levels in healthy adults ($P < 0.05$). Dancing could be demonstrated to be a practical non-medicinal approach to help prevent metabolic syndrome and reduce inflammation through increased cortisol production in healthy adults.

Keywords
Metabolic syndrome; stress hormone; inflammation; dancing exercise; healthy adults

1. Introduction

The role of a sedentary lifestyle in the pathogenesis of cardiovascular, hepato-renal, metabolic disease, and lipid profile is becoming increasingly better understood as medical research advances. Research suggests that a sedentary lifestyle contributes to an increased risk of developing cardiovascular disease, hepato-renal disease, and type 2 diabetes, as well as hepatic steatosis and metabolic syndrome [1-4]. This is because physical inactivity can lead to a decreased ability to clear lipids from the body, difficulty metabolizing glucose, and poor circulation. Additionally, those with a sedentary lifestyle are at an increased risk of hypertension, elevated cholesterol, and diabetes. In addition to increasing the risk for certain diseases, a sedentary lifestyle has also been linked to poor lipid profiles. Studies have shown that physical inactivity is associated with higher levels of total cholesterol, low-density lipoprotein (LDL), and triglycerides, as well as lower high-density lipoprotein (HDL) levels [5, 6].

Metabolic Syndrome is a complex disorder characterized by metabolic and inflammatory components. Inflammatory mechanisms have been shown to play a vital role in chronic disease development, triggered by the release of cytokines (IL-6 & IL-10) and stress hormones (cortisol & epinephrine) from tissue [7, 8]. These modulate the cascade's amplification and regulation. Cytokines are involved in physiological functions like muscle and bone turnover, immunoregulation, and hematopoiesis and are linked to chronic noncommunicable diseases such as atherosclerosis, cardiovascular disease, etc. [9]. However, to improve overall well-being, regular physical activity is essential to protect against and treat these chronic diseases.

Dancing exercise is a form of physical activity that is gaining increasing attention for its potential to improve overall health [10]. Dancing is a physical activity that involves a range of physical movements. It requires balance, agility, rhythm, coordination, flexibility, strength, and cardiovascular endurance [11]. Generally, it is performed to music and can be rhythmic and athletic. It includes a variety of styles such as ballroom, hip hop, breakdancing, African, Latin, salsa, Bollywood, disco, jazz, folk, freestyle, and modern [12]. Aside from its physical fitness benefits, dancing can also improve psychological health through stress relief, mood enhancement, and enhanced self-esteem. In particular, dance is a safe and effective form of exercise for improving physical fitness and health outcomes [12]. Dance has also been associated with numerous benefits, including increased physical activity, improved aerobic fitness, balance, flexibility, and physical function [13]. Several studies have reported the effects of various types of dancing exercise on cardiovascular parameters, hepato-renal functions, metabolic markers, and lipid profiles individually. The results of these studies suggest that dancing exercise can have beneficial effects on all these health parameters. For instance, one study showed that dancing can significantly improve resting heart rate, blood pressure, and oxygen saturation [14]. Other studies have found that dancing can improve lipid profiles, such as decreased total cholesterol, low-density lipoprotein, and triglyceride levels [15]. Finally, dancing has also improved metabolic markers such as reduced glucose and insulin levels [16]. Animal studies have further supported the health benefits of dancing exercise. Animals that underwent dancing exercise showed improved metabolic and cardiovascular indices compared to those without exercise [16]. Furthermore, dancing exercise reduces inflammation and enhances liver and renal function. Based on the above, the present study was designed to examine the potential health effects of dancing exercise as a non-pharmacological therapeutic regimen on cardiovascular, hepato-renal, and metabolic health and lipid profile.

2. Materials and Methods

2.1 Materials

The OneTouch® Ultra™ diagnostic kit was employed to measure glucose levels. In contrast, enzyme-linked immunosorbent assay (ELISA) kits were obtained from R&D systems (USA) and Thermo Fisher Scientific (Waltham, Massachusetts, United States) to ascertain various biochemical parameters.

2.2 Informed Consent and Ethical Approval

Informed consent forms from the Human Research Ethical Committee of Delta Central College of Management and Sciences (DECCOMS) were acquired and distributed among the intended participants. All participants were permitted to participate in the dancing exercise, and the Human Research Ethical Committee DECCOMS granted approval for the study (DECCOMS/HREC/23/79).

2.3 Experimental Protocols

Forty adults (20-40 years old) of both genders were chosen for the experiment, with the average age of participants being calculated. No individuals with a history of familial hyperlipidemia, hypertension, diabetes mellitus, or those on hypolipidemic drugs were permitted

to participate in the study. The eligible subjects were male and female, non-smoking, non-obese, and non-alcoholic individuals. A total of 40 people took part in the study, recruited from a pool of 50 volunteers. Participants were split equally between men and women, with 20 of each gender chosen for the study following an initial screening process. For the experiment, 40 healthy young adults were chosen and split into two separate groups - Pre-dancing and post-dancing intervention groups. The post-dancing group was required to participate in 15 minutes of dancing per day on a five-day-a-week basis for an overall duration of 4 weeks. The hip-hop dance style (a range of street dance styles primarily performed to hip-hop music) was utilized as a dancing exercise program led by a certified dance instructor. The study used a pre-test and post-test design, with participants acting as controls. This design was to allow for the comparison of metabolic functions before and after the dancing exercise program.

2.3.1 Size of Participants

The sample size for this study was calculated using the power analysis method, which was conducted using G*Power software, taking into account the effect size, power, and significance level. A high effect size (f) of 0.8 was selected based on previous research on the effects of exercise on metabolic functions. With a power (1-β) of 0.73, a significance level of 0.05, and several groups (k = 2), the minimum required sample size was determined to be 44 participants. An alpha level of 0.05 was considered the accepted significance level. The power of 0.73 indicates a 73% chance of detecting a significant effect if it exists. Finally, the number of groups (k = 2) refers to the intervention group (participants who will undergo dancing exercise) and the Pre-dancing group (same participants before the dancing intervention). Based on these parameters, the power analysis determined that a minimum of 44 participants is required for this study (22 participants in each group). This sample size was considered appropriate to detect a large effect size with a power of 0.73 and an alpha level of 0.05. However, to account for potential attrition or dropouts, the sample size was increased by 10%, resulting in a total sample size of 50 participants (25 participants in each group).

2.4 Blood Collections

Blood samples were taken from the participants before and after their exercise to evaluate how their body reacted to the activity. The blood samples were taken in a sitting position and were gathered both before (24 hours prior) and after exercise (one hour and 24 hours after). 10 mL of blood was collected from intravenous sites into heparinized bottles before and after physical exercise. The blood samples were immediately placed in an ice bath and centrifuged at 2500 rotations per minute for 10 minutes. Subsequently, aliquots of the plasma were harvested from the centrifuged blood sample and stored at -80°C until analysis**.**

2.5 Biochemical Assay

2.5.1 Measurement of Insulin

Plasma insulin was measured and studied through the ELISA technique (Research and Development Systems, United States of America).

2.5.2 Blood Glucose Estimation

The OneTouch® Ultra™ diagnostic kit measured the body's response to exercise by analyzing control and post-exercise intravenous blood samples through a glucose assay.

2.5.3 Homeostatic Model Assessment (HOMA)

The Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) can be used to measure the body's response to exercise by analyzing pre- and post-exercise intravenous blood samples. According to Chijiokwu et al. [17], the HOMA-IR value is calculated using the following equation: HOMA-IR = [glucose (mg/dL) × insulin (µU/mL)]/405.

2.5.4 Lipid Profile Assessment

The concentration of triglycerides was determined utilizing the Triglyceride Assay Kit from Randox Laboratories Ltd. in Crumlin, UK. The assay kit employs a modified GPO-PAP method as described by Manna [18]. The results were acquired and the absorbance was measured at 500 nm using a spectrophotometer. Total cholesterol was measured using the Total Cholesterol Assay Kit provided by Randox Laboratories Ltd. in Crumlin, UK. This kit employs a modified version of the CHOD-PAP method, as outlined by Manna in 2017, to measure total cholesterol levels accurately. The results were then obtained and the absorbance was read at 500 nm using a spectrophotometer. High-density lipoprotein was measured using the Randox direct HDL-cholesterol kit from Randox Laboratories Ltd., located in Crumlin, UK. The outcomes were acquired and the absorption readings were taken using a spectrophotometer set to 500 nm. Low-density lipoprotein was measured using the Randox direct LDL-cholesterol kit manufactured by Randox Laboratories Ltd. in Crumlin, UK. The results were analyzed using a spectrophotometer at a wavelength of 500 nm. This kit was chosen over the Friedewald equation, as proposed by Friedewald and colleagues in 1972, due to its ability to avoid potential errors caused by the presence of triglycerides.

2.5.5 Liver Marker Enzymes

The activities of gamma-glutamyltranspeptidase (GGT), alkaline phosphatase (ALP), acid phosphatase (ACP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), lactate dehydrogenase (LDH) and sorbitol dehydrogenase (SDH) were evaluated by following the guidelines provided by the suppliers, QumicaClinicaAplicada S.A. (Spain) and Worthington Biochemical, Lakewood respectively.

2.5.6 Renal Function Markers

The Enzymatic Colometric method was employed to analyze uric acid and creatinine using the BT3000 biochemistry autoanalyzer [19]. The BT3000 autoanalyzer utilizes the Uricase enzyme to assess uric acid levels, triggering a reaction with the chromogenic substrate to generate a blue product. The intensity of the resulting color directly correlated with the quantity of uric acid in the sample, and the spectrophotometer was used to measure the results at a designated wavelength. As for creatinine analysis, the BT3000 autoanalyzer employs the Creatininase enzyme to catalyze

the reaction between creatinine and the chromogenic substrate, resulting in a red-colored product. Similar to the uric acid analysis, the color intensity was directly proportional to the creatinine levels in the sample, and the spectrophotometer was used to measure the results at a specific wavelength.

2.5.7 Inflammatory Markers

High-sensitivity ELISA kits were employed to analyze IL-6, IL-10, and CRP measurements following the standards proposed by Pars Azmoon Co, Iran.

2.5.8 Stress Hormone Markers

Following their guidelines, the epinephrine and cortisol concentrations were analyzed using an ELISA kit from IBL, Hamburg, Germany.

2.6 Assessment of Blood Pressure

After 5-10 minutes of quiet rest in a sitting position, the resting systolic and diastolic blood pressures were determined indirectly in the right arm using the Omron Automatic Digital Blood Pressure Monitor (model no. HEM 713C), endorsed by the American Heart Association. This measurement was performed each day between 8:00 am and 11:30 am for 28 days, following the protocol of Dudeja et al. [20]. The blood pressure monitor was set to a maximum value of 200 mm Hg throughout the exercise. The cuff was placed evenly and snugly on the bare arm, with the bottom edge 2.5 cm above the antecubital fossa. The monitor was ready for use within seconds after pressing the ON button. Pressing the START button initiated inflation with a buzzing sound, increasing at a geometric progression until reaching the maximum preset value of 200 mm Hg. From this point, the cuff began to deflate at an arithmetic progression and in rhythm with the heart rate. The final display showed the systolic and diastolic blood pressures (in mm Hg) and the heart rate (in beats per minute). The blood pressure of each subject was recorded on the Raw Data Sheet. Two measurements were taken on the right arm for each subject, with a minimum of one minute between readings. The average of the two readings was recorded as the systolic pressure over the diastolic pressure in millimeters of mercury.

2.7 Statistical Analysis

The results were processed with MS Excel and analyzed through SPSS 12.0 software. Data was presented as mean and standard deviation (SD). An Analysis of Variance (ANOVA) was conducted to determine if there were significant differences between the groups. A Post Hoc test was then applied to analyze these differences further. The substantial level set for all tests was $P < 0.05$.

3. Results

3.1 Effect of Post-Dancing Exercise on Metabolic Profile

The glucose, insulin, and HOMA-IR of male and female participants are presented in Table 1. The result showed a significant ($p < 0.05$) reduction in the glucose, insulin, and HOMA-IR of both male and female participants after 4 weeks of the dancing exercise intervention compared to their

baseline value before the beginning of the study. The glucose, insulin, and HOMA-IR of male and female participants after 24 hours of the dancing exercise were more significantly ($P < 0.05$) decreased compared to the pre-and1-hour post-dancing exercise, respectively.

Table 1 Effect of post-dancing exercise on Metabolic Profile of Male and Female Adults participants.

Parameters	Male participants			Female participants		
	Pre-dancing	**1 hr Post-dancing**	**24 hr Post-dancing**	**Pre-dancing**	**1 hr Post-dancing**	**24 hr Post-dancing**
Glucose (mg/dl)	10.2 ± 2.4	6.3 ± 0.9*	6.9 ± 1.3*a	11.2 ± 3.2	7.4 ± 0.7*	7.0 ± 0.5*a
Insulin (µU/ml)	18.6 ± 4.9	9.3 ± 0.8*	11.2 ± 2.1*a	16.6 ± 4.9	7.8 ± 0.3*	14.0 ± 2.1*a
HOMA index	0.5 ± 3.2	0.16 ± 0.02*	0.10 ± 0.04*a	0.6 ± 1.4	0.12 ± 0.05*	0.11 ± 0.04*a

$P < 0.05$, * when compared to pre-dancing data, $P < 0.05^a$ compared to the 1-hour after-dancing group. HOMA index: Homoeostasis Model Assessment index

3.2 Effects of Post-Dancing Exercise on Cardiovascular Parameters

The results for SBP, DBP, and RHR are presented in Table 2. The post-dancing exercise group shows a significant ($p < 0.05$) reduction in SBP, DBP, and RHR for males compared to pre-dancing exercise, respectively. Interestingly, the 24-hour post-dancing exercise group in both genders reveals a more significant decrease in SBP, DBP, and RHR compared to the pre- and 1-hour post-dancing exercise, respectively.

Table 2 Effects of Post-dancing Exercise on SBP, DBP, and RHR in adult participants.

Parameter	Male participants			Female participants		
	Pre-dancing	**1 hr Post-dancing**	**24 hr Post-dancing**	**Pre-dancing**	**1 hr Post-dancing**	**24 hr Post-dancing**
SBP (mmHg)	133.77 ± 8.42	129.58 ± 8.32*	121.54 ± 6.43^{*a}	135.82 ±5.63	120.58 ± 7.22*	110.35 ± 6.01^{*a}
DBP (mmHg)	87.77 ± 5.10	80.10 ± 6.87*	75.10 ± 6.87^{*a}	85.34 ± 8.01	81.23 ± 7.66*	73.44 ± 4.95^{*a}
RHR (beats/min)	78.10 ± 7.32	72 ± 5.16*	70.4 ± 31.9^{*a}	80.22 ± 6.55	75 ± 7.48*	70.03 ± 35.4^{*a}

$P < 0.05$, * when compared to pre-dancing data, $P < 0.05^{a}$ compared to the 1-hour after-dancing group, SBP = systolic blood pressure, DBP = diastolic blood pressure, RHR = resting heart rate.

3.3 Effects of Post-Dancing Exercise on Liver Marker Enzymes

Table 3 indicates that ALP and LDH had a significant increase ($p < 0.05$) compared to pre-exercise levels, while ALT, AST, and GGT had a significant decrease ($p > 0.05$). Notably, these differences were more pronounced 24 hours after the dancing exercise than pre- and 1-hour post-dancing.

Table 3 Effects of Post-dancing Exercise on Liver Marker Enzymes in male and female health adults volunteer.

Parameter	Male participants			Female participants		
	Pre-dancing	**1 hr Post-dancing**	**24 hr Post-dancing**	**Pre-dancing**	**1 hr Post-dancing**	**24 hr Post-dancing**
ALT (U/L)	52.9 ± 11.4	49.2 ± 14.1*	43.3 ± 10.2^{*a}	59.8 ± 11.5	53.6 ± 16.0*	50.2 ± 10.3^{*a}
AST (U/L)	57.9 ± 5.8	39.5 ± 6.0*	32.8 ± 3.6^{*a}	37.2 ± 8.0	34.6 ± 8.4*	30.0 ± 3.7^{*a}
ALP (U/L)	149.8 ± 33.7	156.2 ± 58.1*	160.4 ± 31.9^{*a}	142.3 ± 24.2	148.6 ± 71.2*	152.5 ± 26.8^{*a}
LDH (U/L)	1136.3 ± 374.8	1171.3 ± 390.3*	1132.1 ± 269.2	1100.6 ± 189.4	1282.4 ± 299.3*	1108.1 ± 164.2
GGT (U/L)	42.8 ± 12.4	52.3 ± 18.3**	39.8 ± 12.4	48.2 ± 14.6	53.4 ± 22.1**	41.5 ± 12.9

$P < 0.05$, *when compared to the pre-dancing group, $P < 0.05^{a}$ when compared to the post 1-hour post-dancing group. Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), Gamma GlutamylTransferase (GGT), Alkaline Phosphatase (ALP), and Lactate Dehydrogenase (LDH).

3.4 Effects of Post-Dancing Exercise on Lipid Profile

The lipid profile revealed that after 1 hour and 24 hours of dancing exercise, there was a significant decrease in TC, TG, and LDL-C when compared to pre-exercise levels ($P < 0.05$). Additionally, HDL-C had a notable increase in the 1-hour and 24-hour post-exercise group ($P < 0.05$) compared to the pre-dancing exercise level. The 24-hour post-exercise group experienced a decrease in total cholesterol (TC), triglyceride (TG), and low-density lipoprotein cholesterol (LDL-C) relative to the 1-hour post-exercise group, as evidenced by statistical significance ($P < 0.05$) (Table 4). Conversely, the 24-hour group had significantly higher high-density lipoprotein cholesterol (HDL-C) than the 1-hour group ($P < 0.05$) (Table 4).

Table 4 Effects of Post-dancing Exercise on Lipid profile in male and female healthy adults.

Parameter	Male participants			Female participants		
	Pre-dancing	**1 hr Post-dancing**	**24 hr Post-dancing**	**Pre-dancing**	**1 hr Post-dancing**	**24 hr Post-dancing**
TC (mg/dl)	168.8 ± 11.2	150.2 ± 9.8*	140.5 ± 7.3^{*a}	165.63 ± 4.13	160.58 ± 6.62*	152.28 ± 6.42^{*a}
TG (mg/dl)	110.3 ± 4.9	94.8 ± 7.2*	70.8 ± 7.7^{*a}	115.14 ± 6.08	100.18 ± 5.52*	92.43 ± 5.38^{*a}
HDL-C (mg/dl)	36.8 ± 7.8	40.6 ± 4.8*	50.8 ± 5.7^{*a}	39.3 ± 5.7	45.76 ± 7.4*	53.11 ± 25.9^{*a}
LDL-C (mg/dl)	99.2 ± 6.9	92.3 ± 9.2*	85.7 ± 5.6^{*a}	97.3 ± 4.82	85 ± 8.15*	70.42 ± 41.2^{*a}

$P < 0.05$, * when compared to pre-dancing data, $P < 0.05^{a}$ compared to the 1-hour after-dancing group. TC = total cholesterol, TG = triglyceride, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol.

3.5 Effects of Post-Dancing Exercise on Liver Marker Enzymes

1-hour post-dancing exercise indicates that Aminotransferase, Creatinine, and Uric acid had a significant increase ($p < 0.05$) when compared to pre-exercise levels, whereas 24-hour post-dancing exercise means that Aminotransferase, Creatinine, and Uric acid had a significant decrease ($p < 0.05$) when compared to pre-exercise levels ($p > 0.05$). Notably, a substantial decrease in Aminotransferase, Creatinine, and Uric acid was more pronounced 24 hours after the dancing exercise than the pre- and 1-hour post-dancing exercise as revealed in Table 5.

Table 5 Effects of Pre-dancing and Post-dancing Exercise on renal function in male and Female Adult participants.

Parameters	Male participants			Female participants		
	Pre-dancing	1 hr Post-dancing	24 hr Post-dancing	Pre-dancing	1 hr Post-dancing	24 hr Post-dancing
Creatinine (mg/dL)	0.6 ± 2.9	1.4 ± 0.8*	0.5 ± 2.6*a	0.4 ± 0.5	0.7 ± 0.5*	0.5 ± 0.3*a
Uric acid (mg/dL)	3.3 ± 2.5	4.5 ± 1.3*	3.2 ± 3.4*a	0.28 ± 0.6	0.32 ± 0.2*	0.29 ± 0.4*a

$P < 0.05$* when compared to pre-dancing exercise, $P < 0.05^a$ when compared to the 1-hour post-dancing group

3.6 Effects of Post-Dancing Exercise on Stress Hormone Indices

The results for serum cortisol and adrenalin are presented in Table 6. Serum concentrations of cortisol and adrenalin significantly increased after 1 hour of dancing exercise in healthy male and female adults. However, after 24 hours of post-dancing exercise, the serum cortisol and adrenalin levels showed a significant ($p < 0.05$) reduction compared to pre-dancing and 1-hour post-dancing exercise, respectively.

Table 6 Effects of Post-dancing Exercise on stress hormone in male and Female Adult participants.

Parameters	Male participants			Female participants		
	Pre-dancing	1 hr Post-dancing	24 hr Post-dancing	Pre-dancing	1 hr Post-dancing	24 hr Post-dancing
Cortisol (ng/mL)	52.1 ± 2.1	62.3 ± 1.6*	51.9 ± 1.4a	52.9 ± 1.2	68.5 ± 2.3*	55.8 ± 1.7*a
Adrenalin (ng/mL)	0.36 ± 0.7	0.83 ± 1.1*	0.35 ± 0.3a	0.40 ± 0.5	0.89 ± 0.8*	0.45 ± 0.4*a

$P < 0.05$* compared to baseline data and $P < 0.05$a compared to the pre-dancing group.

3.7 Effects of Post-Dancing Exercise on Inflammatory Cytokine Markers

The results for serum IL-6, IL-10, and CRP are presented in Table 7. Serum concentrations of IL-6, IL-10, and CRP significantly increased after 1 hour of dancing exercise in healthy male and female

adults. However, after 24 hours of post-dancing exercise, the serum IL-6 and CRP levels showed a significant ($p < 0.05$) reduction with corresponding increased IL-10 levels compared to pre-dancing and 1-hour post-dancing exercise, respectively.

Table 7 Effects of Post-dancing Exercise on Inflammatory Cytokine in Male and Female Adult Participants.

Parameters	Male participants			Female participants		
	Pre-dancing	1 hr Post-dancing	24 hr Post-dancing	Pre-dancing	1 hr Post-dancing	24 hr Post-dancing
IL-6 (pg/mL)	1.2 ± 0.2	1.6 ± 0.1*	0.9 ± 0.4a*	1.4 ± 0.2	1.7 ± 0.3*	1.1 ± 0.2*a
IL-10 (pg/mL)	2.39 ± 0.1	2.95 ± 0.3*	3.04 ± 0.6a*	2.40 ± 0.1	2.79 ± 0.4*	2.99 ± 0.3*a
CRP (mg/L)	0.46 ± 0.2	0.56 ± 0.5*	0.42 ± 0.6a*	0.44 ± 0.4	0.62 ± 0.2*	0.40 ± 0.1*a

P < 0.05* compared to baseline data and P < 0.05a compared to the pre-dancing group. IL, interleukin; CRP, C-reactive protein.

4. Discussion

There is increasing evidence that incorporating regular physical exercise in one's everyday life is an effective way to improve overall mental and physical health [21]. This is especially true for individuals with certain health conditions, such as cardiovascular diseases, diabetes, or metabolic syndrome. In particular, dancing exercise as a therapeutic regimen has been studied for many years as an alternative for those looking to improve their cardiovascular, hepato-renal, metabolic health, and lipid profile. This study aims to analyze current research on the Mechanisms of post-dancing exercise on healthy adults and provide insight into the potential benefits of utilizing dancing exercise as a non-pharmacological regimen to optimize health and well-being.

Dancing has been around for centuries, but never before has it been studied as a therapeutic regimen to improve the health and well-being of healthy adults [22, 23]. This area of research was brought to light in recent studies that are beginning to explore the potential benefits of dancing for non-pharmacological treatment of cardiovascular, hepato-renal, metabolic health, and even lipid profiles in healthy adults.

Interestingly, the results of the experiment showed a decrease in glucose and insulin and a decrease in HOMA-IR levels in healthy adults after engaging in a tailored dance exercise compared to the levels prior to engaging in the dance exercise. Glucose is a sugar the body needs to produce energy, and insulin is an important hormone that helps regulate the amount of glucose in the bloodstream. Thus, when dancing, the body tends to go through a series of physical movements that require energy, provided by burning glucose. The Homoeostasis Model Assessment (HOMA) index is a measure of the relative levels of glucose and insulin in the body [17]. It is used as a marker of metabolic health and an indicator of insulin resistance. A decrease in the HOMA index indicates a decrease in glucose and insulin levels, leading to improved metabolic health. The decreased Homeostasis Model Assessment (HOMA) index obtained as a result of participating in the dancing exercises shows an improvement in the ability of the body to regulate its internal environment compared to the pre-exercise measurements. Normally, The HOMA index is based on the concentrations of insulin and plasma glucose and is usually used to describe a person's insulin sensitivity. In other words, a decrease in the HOMA index indicates that a person's body

can better regulate their insulin levels, leading to better overall health. Here, dancing exercises improve insulin sensitivity, which could help reduce the risk of diabetes, which is a long-term condition caused by the body's not producing enough insulin or not being able to use insulin effectively. These findings are in agreement with a previous study conducted by Camacho-Lemus et al. [24] and Marques et al. [25] on the effects of dancing exercise on metabolic health, where they observed a mean decrease in glucose, insulin, and HOMA-IR levels. Therefore, dancing can help to reduce glucose levels in the blood. Additionally, dancing can cause the body to produce less insulin, which can also help to reduce the amount of glucose in the bloodstream. As a result, dancing exercise can help maintain metabolic health compared to before the dancing exercise.

Blood pressure and resting heart rate have long been recognized as essential factors in overall health. They are linked to the development of various chronic diseases like cardiovascular diseases, which are associated with dyslipidemia and dyslipoproteinemia [26, 27]. This is an important consideration when assessing an individual's health, as elevated heart rate and/or systolic blood pressure can lead to further health complications. Research in recent decades has linked blood pressure to lipid and lipoprotein sources, suggesting that dietary interventions may be an essential intervention strategy [28]. Healthy eating and exercise are commonly recommended strategies to help improve blood pressure, and optimizing dietary and lifestyle factors can help reduce the risk of developing chronic diseases [29]. However, the blood pressure and resting heart rate in post-dancing exercise were studied in the present experiment, and it was revealed that there was a significant reduction in blood pressure indices (systolic and diastolic) and resting heart rate among the 1-hour and 24-hour post-dancing male and female group after 4 weeks of dancing exercise when compared to pre-dancing data. Similar observations have been noted where blood pressure and heart rate reduction was noted after dance-based exercise among volunteers aged 20 to 30 years [30, 31]. This reduction in heart rate and blood pressure indicates a shift in the balancing components of the autonomic nervous system towards the parasympathetic activity [32]. This modulation of autonomic nervous system activity might have been brought about through the conditioning effect of dancing exercise on autonomic functions and mediated through the limbic system and higher areas of the central nervous system [32]. Regular dancing practice could increase the baroreflex sensitivity and decrease the sympathetic tone, thereby restoring blood pressure to average level in patients with essential hypertension. Dancing could also help to modify the state of anxiety, thus reducing stress-induced sympathetic overactivity and decreasing arterial tone and peripheral resistance, eventually lowering diastolic blood pressure and heart rate for better peripheral circulation and blood flow to the tissues. The results of this study suggest that dance-based exercise can reduce high blood pressure and heart rate among some healthy adults.

Lipids and lipoproteins are essential components of the human body and play multiple roles in maintaining normal physiology. Lipids are found in the form of triglycerides, free fatty acids, cholesterol, and other combinations of lipids known as lipoproteins. Lipoproteins are essential for transporting lipids in the bloodstream and contributing to the stability of cell membranes. The lipids and lipoprotein profile are critical to maintaining our cardiovascular and metabolic health. Moreover, elevated levels of lipids (triglyceride levels, total cholesterol) and lipoprotein like LDL in the blood significantly increase the risk of stroke and other CVD-related conditions [33]. Thus, it is essential to evaluate these biomarkers regularly to ensure optimal cardiovascular health. Accordingly, our results from this present study show reduced triglyceride levels, total cholesterol,

LDL cholesterol, and increased HDL in the post-dancing exercise group compared to the pre-dancing exercise group. This result is consistent with the findings of Forouhi et al. 2017. Furthermore, the study indicated that dancing could benefit cardiovascular and metabolic health, as evidenced by decreased triglyceride levels, LDL cholesterol, and increases in HDL cholesterol levels.

The impact of dancing exercise on liver health parameters can be measured in terms of increasing levels of Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), Alkaline Phosphatase (ALP), Lactate Dehydrogenase (LDH) and Gamma GlutamylTransferase (GGT) when compared to the levels before the dancing exercise. ALT and AST are enzymes released by the liver and are used to measure the amount of damage to the liver. Increased levels of these enzymes generally indicate that there is some damage to the liver. The study showed that after 4 weeks of dancing exercise, significant decreases in ALT and AST levels were observed. This decrease is likely due to the release of stress hormones such as cortisol, which reduces inflammation and returns these enzyme levels to a normal range [34]. This suggests that dancing exercise may be an effective treatment to reduce the levels of these enzymes in healthy individuals compared to the pre-dancing group. This result indicates that dancing can be beneficial in decreasing ALT and AST levels and reducing the potential risk of liver injury [35-37]. ALP is an enzyme produced by the liver, bones, and kidneys and is often used to monitor bone growth and diagnose osteoporosis [38]. Elevated levels are associated with physical activity, such as fitness, weight loss, and a healthy diet [38]. Dance, as an aerobic activity, was shown to increase ALP levels. Thus, increased ALP levels following dancing may be evidence of physical health benefits associated with improved liver health and weight loss [39, 40]. Furthermore, ALP levels increasing after dancing could be an indication of increased bone health and improved muscle function. LDH, or lactate dehydrogenase, is an enzyme found in the body's cells and is associated with energy metabolism. It was observed in this study that after engaging in dancing exercises, LDH levels can temporarily increase significantly after 1-hour post-dancing when compared to baseline levels (Pre-dancing exercise group). This could result from increased activity of the muscles used during the activity [41]. This lactate dehydrogenase (LDH) increase after dancing could be linked to improved aerobic endurance and muscular efficiency. Notably, this increase in LDH levels is a normal response and typically resolves shortly after 24 hours of post-dancing exercise. GGT levels are important biomarkers that provide insight into liver, kidney, and heart health. High levels of GGT can indicate the presence of a liver disorder. GGT has been reported to break down certain toxins in the liver. After 1-hour Post-dancing, GGT levels were revealed to increase and decrease after 24 hours of dancing; this could indicate how our body adjusts to physical activity, thus suggesting that our organs usually function to compensate for the biological activity [42, 43].

Creatinine is a waste product produced by muscle metabolism and typically eliminated by the kidneys. Elevated levels can often indicate declining kidney function. In this result, Creatinine levels increase after an hour of dancing due to the muscles exerting greater force, which results in the body utilizing more energy and accumulating waste products, including creatinine. However, after 24 hours of dancing exercise, creatinine levels decrease due to the body's natural process for clearing waste products, restoring creatinine levels to normal and re-establishing their ATP levels. This phenomenon has been recognized by the medical community. It is documented in studies such as Seiji, et al. [44], which found increased creatinine levels in marathon runners after a single day of running. This was also supported by research that indicates that during longer aerobic

exercises, such as running, the body tends to become more efficient over time [45-47]. Uric acid is a compound found in the blood, and its levels can be affected by metabolic processes. According to a 2019 study by Carvalho et al., physical activity can significantly affect uric acid levels. Hence, this study showed that uric acid levels increased after one hour of dancing due to the body's production of lactic acid from intense exercise. However, after 24 hours of dancing, the body likely recovers, resulting in a decrease in uric acid levels. This is because the body's metabolites, such as lactic acid, are slowly cleared out during recovery [48]. This suggests regular exercise can help regulate uric acid levels and improve optimal health [49, 50]. Overall, proper and regular dancing exercise increases creatinine and uric acid concentrations, which are all indicators of improved kidney function.

Metabolic syndrome is a cluster of health conditions, including high blood pressure, high blood sugar, abnormal cholesterol levels, and excess body fat around the waist that increase the risk for diabetes, heart disease, and stroke. Inflammatory cytokines are proteins cells release in response to an antigen or stressor that can disturb metabolic and cardiovascular homeostasis. Previous studies have indicated a link between metabolic syndrome and inflammatory cytokines [51, 52]. These present studies have found that dancing can benefit IL-6, IL-10, and CRP levels. After one hour of dancing, these levels increased significantly, indicating an increase in immune system activity. After the 24-hour dancing trial, IL-6 and CRP levels decreased. In contrast, IL-10 levels increased, suggesting a positive immune response was triggered in the body due to dancing for a longer duration [53]. This is likely due to the increased physical activity and the relaxation response generated by dancing longer [54]. In contrast to this present study, it has been shown by Pinto et al. [55] that dancing exercise increased IL-6 and IL-10 in peripheral blood mononuclear cells while decreasing levels of CRP. However, in agreement with this present study, Leelarungrayub et al. [56] show that dancing exercise had a corresponding decrease in IL-6 and CRP, while IL-10 was still elevated. Therefore, dancing appears to have an immediate effect on the levels of these inflammatory proteins.

5. Conclusions

Based on the results of our study, we can conclude that a pharmacological therapeutic regimen of dancing can be used to prevent metabolic syndrome in healthy adult volunteers. This is due to its ability to inhibit the activity of inflammatory cytokines, mediated mainly through its hypercortisolism-inducing effects. This regimen is a promising new treatment option for those at risk of developing metabolic syndrome, and further research is needed to understand the long-term impact of this approach better.

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Author Contributions

Oyovwi Mega Obukohwo: Conceptualization, Investigation, Writing of original draft and revision, Project administration, Supervision, Visualization, Methodology, Formal analysis, revision

and correction; Ohwin Peggy Ejiro: Validation, Writing - review & editing; Oyelere Abosede Oreoluwa & Rotu Rume: Data curation.

Competing Interests

The authors have stated that no competing interests exist.

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